SGA

LIVE VIRTUAL TRAINING

Overview of Machine Learning for Pipeline Integrity Management

February 18, 2025

Anti-trust Reminder

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Meet Your Instructor

Michael Gloven, PE

President, Pipeline-Risk (PLR)

As a founder and entrepreneur, Mike leads Pipeline-Risk (PLR) providing AI based machine learning solutions supporting energy pipeline systems and utilities worldwide. With over 30 years of experience in the oil, gas, and water industries, Mike has founded, co-founded or led numerous technology companies with the objective of improving reliability, risk, integrity and compliance for asset owners and operators.

About Pipeline-Risk (PLR)

Pipeline-Risk (PLR) is an engineering and technology company serving the oil, gas, and water pipeline industries. The company has completed risk projects across hundreds of thousands of miles of pipeline in North and South America using its ML.ai machine learning platform. The objective of ML.ai is to improve the identification, prediction and mitigation of risks for the purposes of improved safety, reliability and cost effectiveness of critical infrastructure.

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More Information

www.pipeline-risk.com

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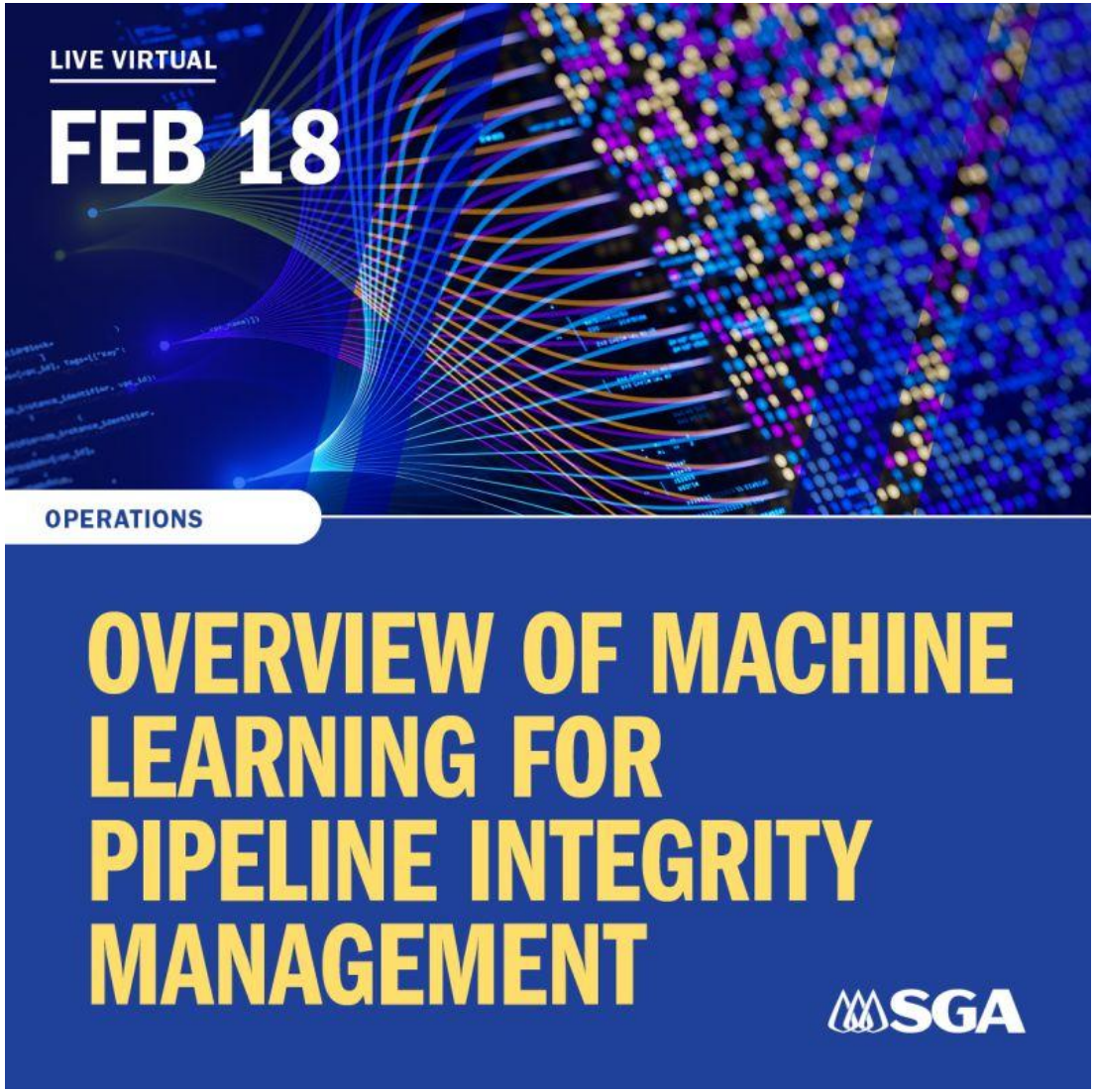
www.youtube.com/@MachineLearningIntegrity

MSGA

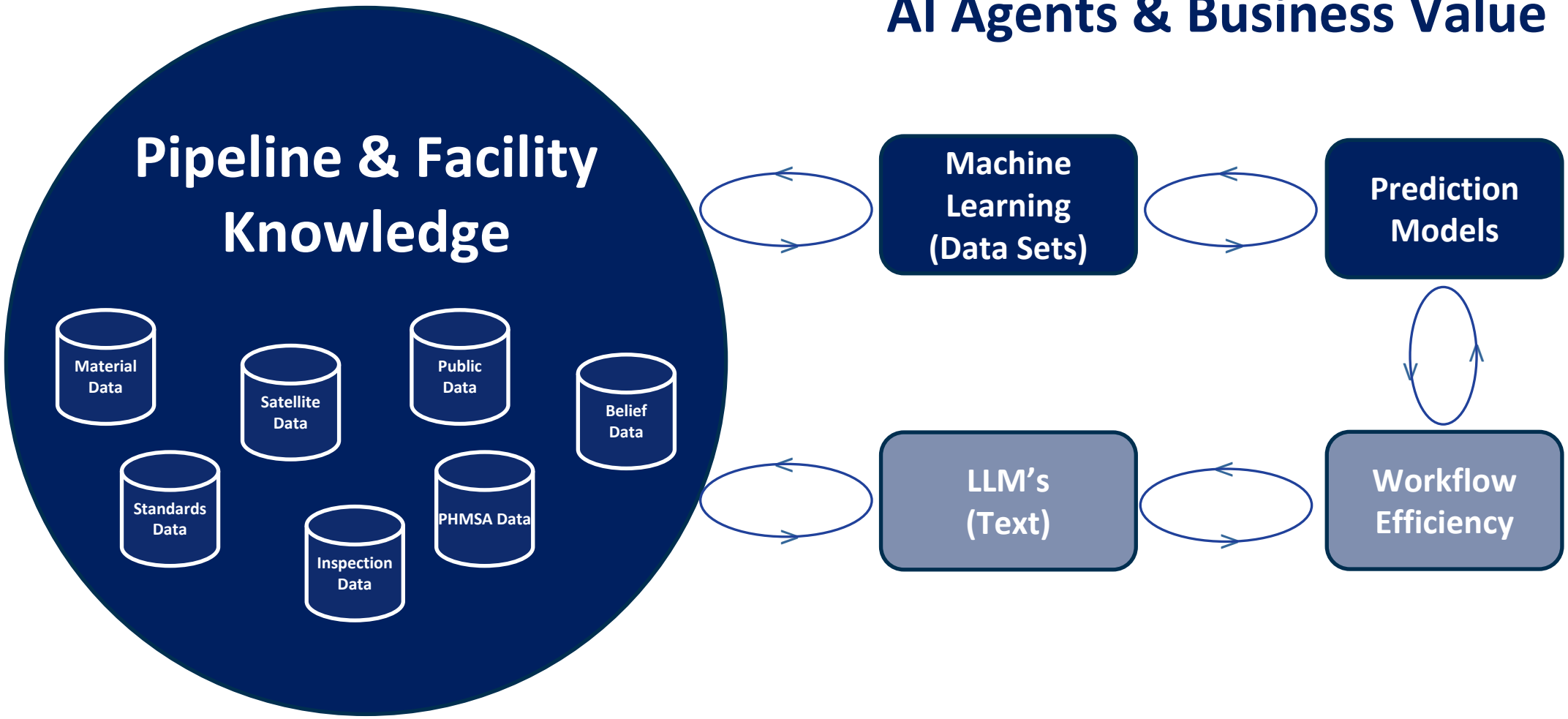


Webinar

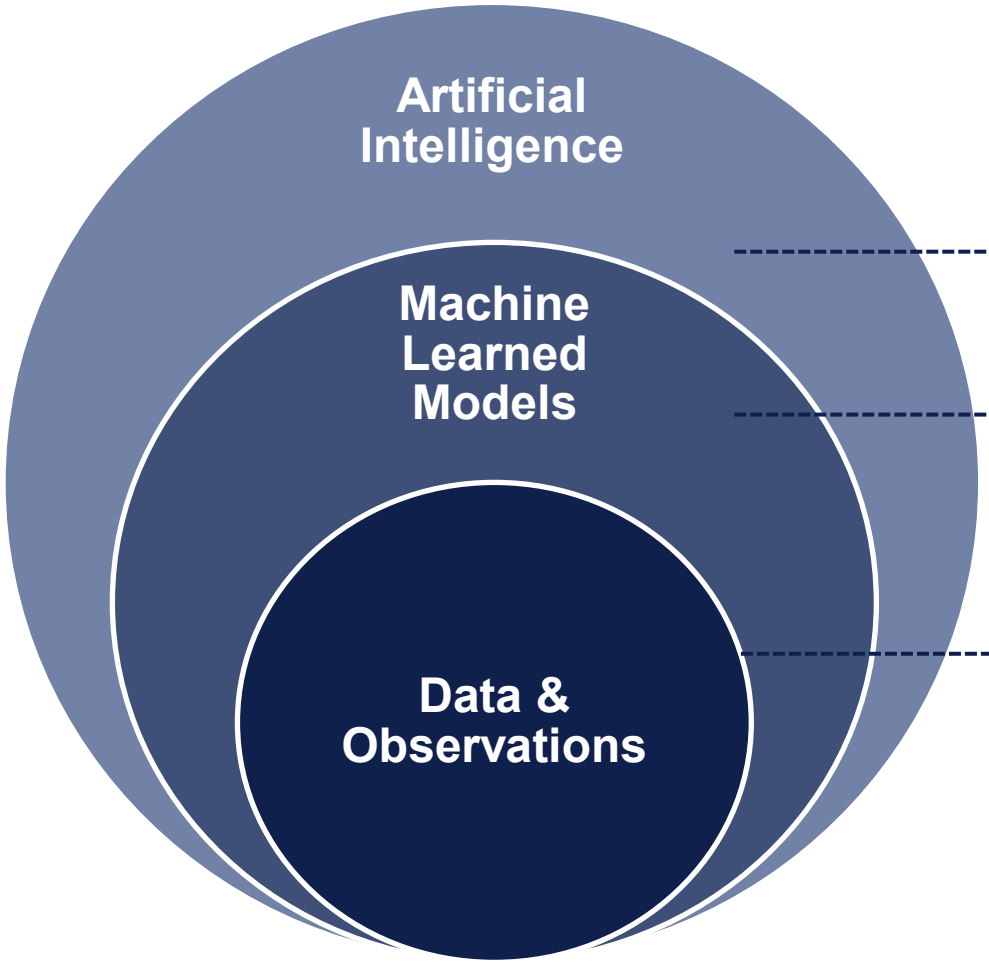
- AI & Machine Learning
- Machine Learning Process
- Use Cases
- Questions

SGA

Big Picture


Pipeline & Facility Knowledge
Material Data
Satellite Data
Public Data
Belief Data
Standards Data
PHMSA Data
Inspection Data
AI Agents & Business Value
Machine Learning (Data Sets)
Prediction Models
LLM's (Text)
Workflow Efficiency

Big Picture



Automated Responses to Data Patterns (Adjust CP, Self-Repair, Reduce Pressure)

Identify Data Patterns Representing & Influencing External Corrosion Observations

External Corrosion **Observations** (Corrosion Defects) and Underlying Influencing Data (Coating Types, Soils, CP Readings, etc.)

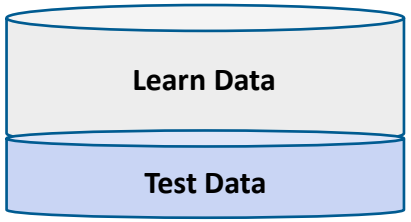
Common Questions

- Are Machine Learned Models an Improvement Over Deterministic Models?
- Do I have Enough of the Right Data?
- Are Patterns Inferential or Predictive? What's the Difference?
- Does the Model Meet Domain Expert Review?
- What Assets can I Apply the Learned Model?
- Is Performance Acceptable for Production Use?

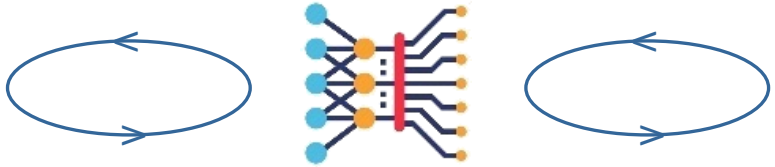
Machine Learning Process

Learning Target
(Integrity, Risk)

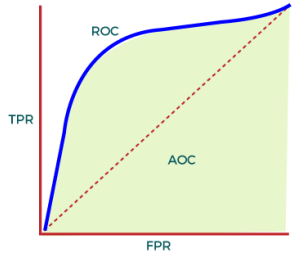
Training Data
(Observations, Predictors)



Learned Model
(Methods, Tuning)



Performance & Insights
(Validation & Acceptance)

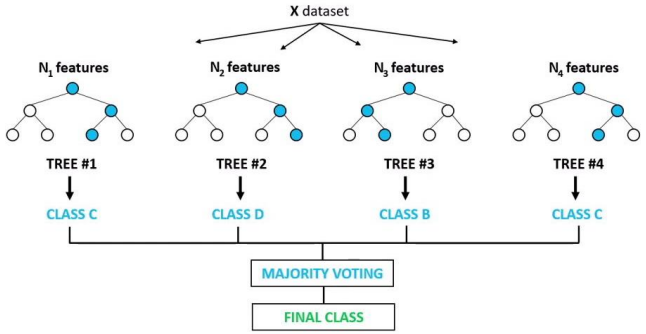


Key Points

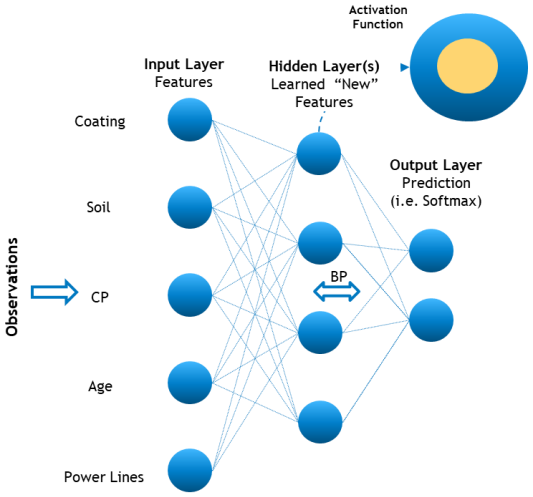
- Data Driven – Leverage Existing Data
- Validated – Models are Explicitly Validated
- Explainable – Models & Results are Fully Transparent & Explainable
- Versatile – Process may be Applied to Wide Range of Integrity & Risk Management Use Cases

Learning Methods

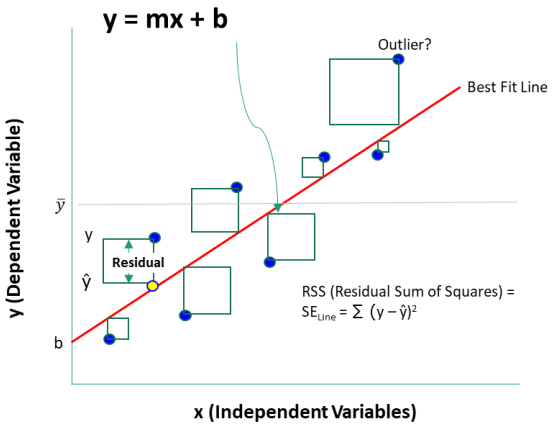
Tree Bagging



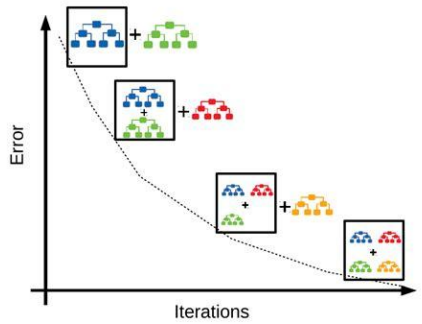
Neural Net



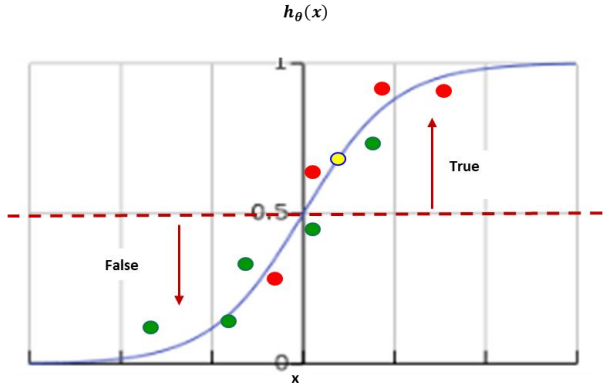
Linear Regression



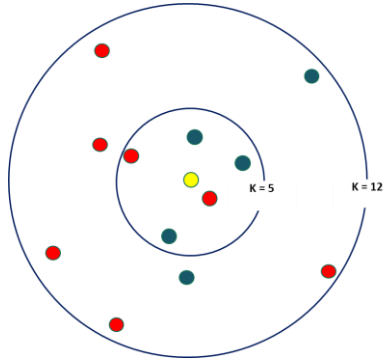
Tree Boosting



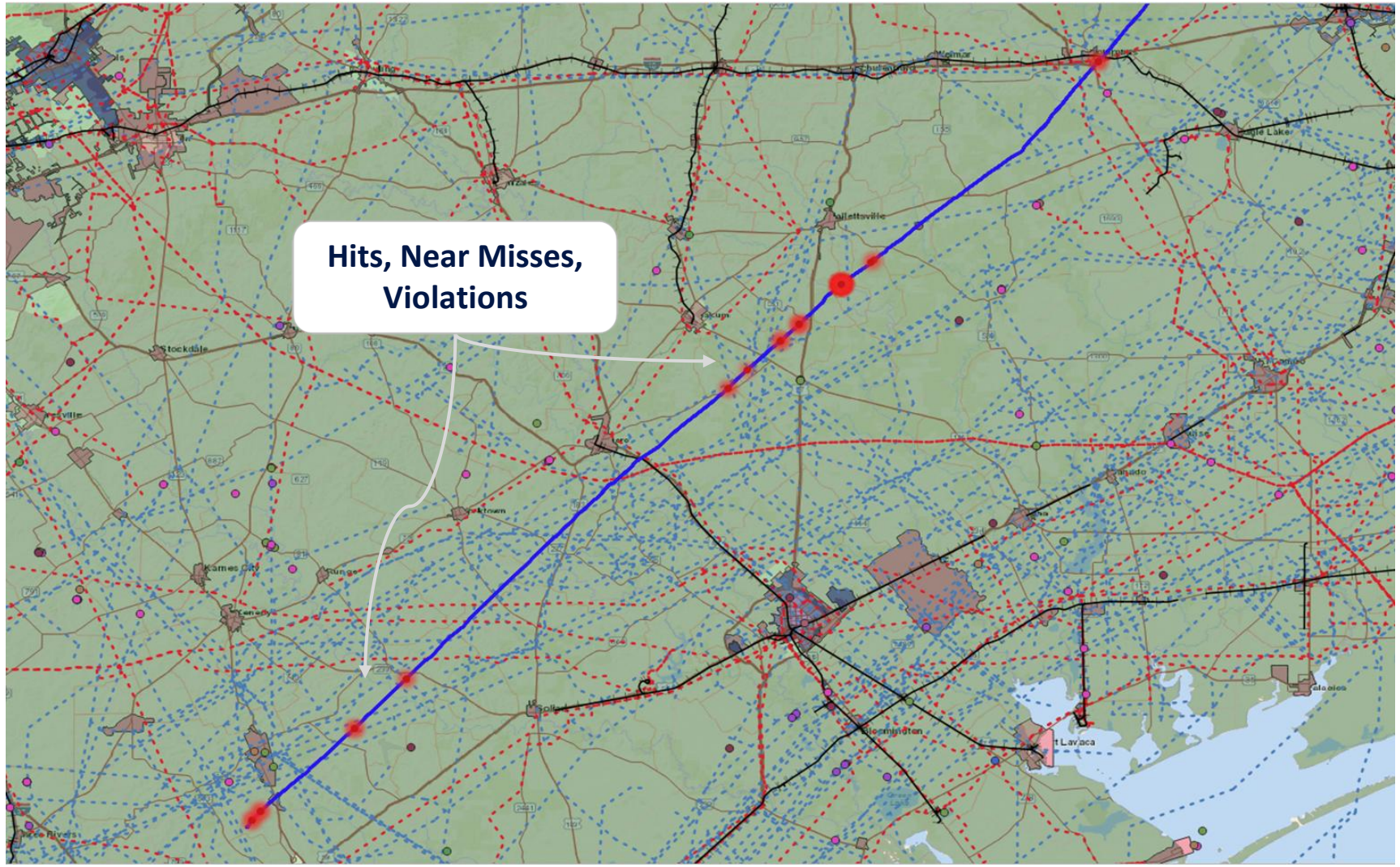
Logistic Regression



KNN



Third Party Damage Susceptibility (Classification)



Training Data

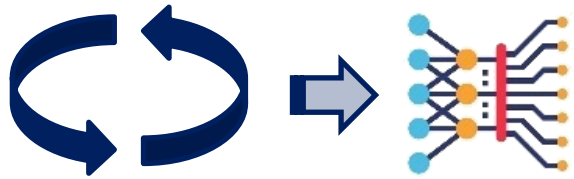
- Hits & Near-Misses
- One-Calls
- Pipe Properties
- Depth Cover
- Activity
- Land-Use
- Crossings
- Structures
- Patrol
- Public Awareness

Learning Target

Predictors

		Class	Diameter	DOC	Farmland	Install_Yr	LineMark	PatroFreq
All	A	A	All	A	All	All	All	All
No_Evidence	F	1.00	8.00	24.00	Not_Farmland	1,980.00	Line_of_Site	Semi-Annual
No_Evidence	F	1.00	8.00	24.00	Not_Farmland	1,980.00		Semi-Annual
No_Evidence	F	1.00	8.00	25.00	Not_Farmland	1,980.00	Line_of_Site	Semi-Annual
No_Evidence	F	1.00	8.00	33.00	Not_Farmland	1,980.00	Line_of_Site	Semi-Annual
No_Evidence	F	1.00	8.00	30.00	Not_Farmland	1,980.00	Line_of_Site	Semi-Annual
One_Call_Violation	T	1.00	8.00	26.00	Not_Farmland	1,980.00	Line_of_Site	Semi-Annual
One_Call_Violation	T	2.00	8.00	26.00	Not_Farmland	1,980.00	Line_of_Site	Semi-Annual
Near_Miss	T	2.00	8.00	29.00	Farmland	1,980.00	Line_of_Site	Semi-Annual
One_Call_Violation	T	2.00	8.00	24.00	Farmland	1,980.00	Line_of_Site	Semi-Annual
Near_Miss	T	2.00	8.00	28.00	Farmland	1,980.00	Line_of_Site	Semi-Annual
Near_Miss	T	2.00	8.00	34.00	Farmland	1,980.00	Line_of_Site	Semi-Annual
Near_Miss	T	2.00	8.00	41.00	Farmland	1,980.00	Line_of_Site	Semi-Annual
No_Evidence	F	2.00	8.00	31.00	Farmland	1,980.00	Line_of_Site	Bi-Weekly
No_Evidence	F	3.00	8.00	24.00	Farmland	1,980.00	Line_of_Site	Bi-Weekly

Training Data



Machine Learning Process

Learned Model

Learned Model Classification Performance

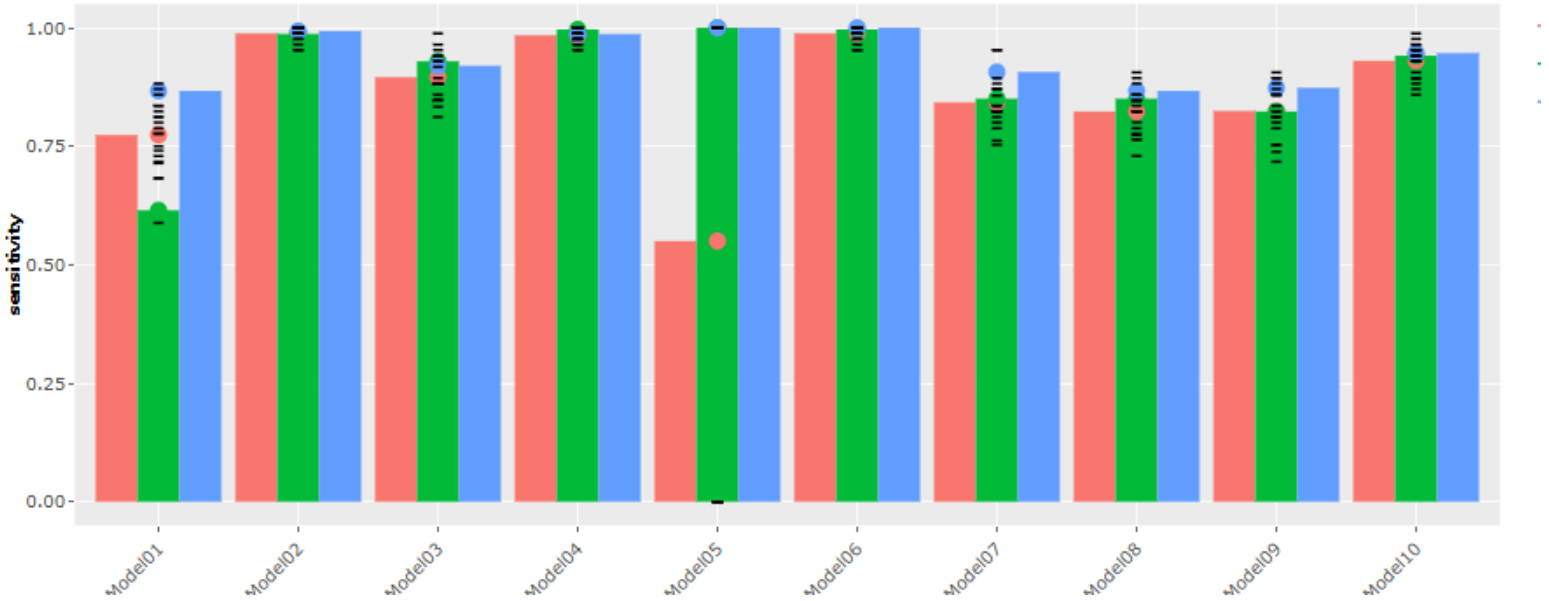
Metrics

- Accuracy
- Sensitivity
- Specificity
- AUC

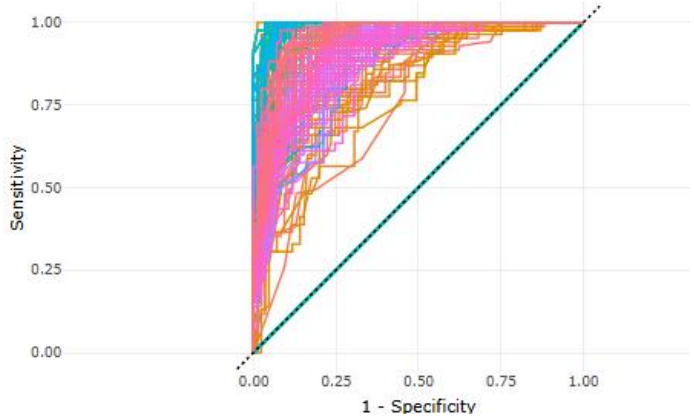
Model

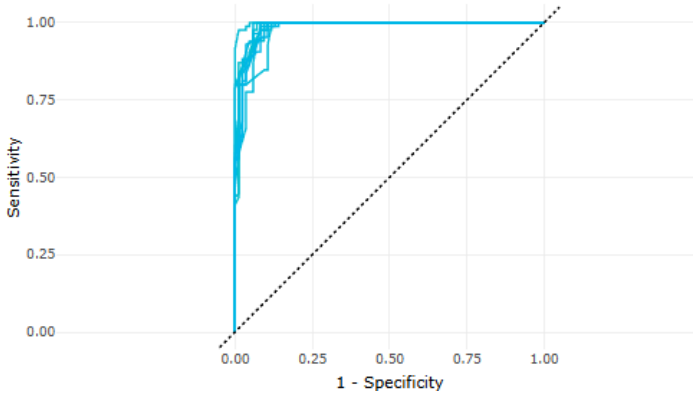
- Xgboost Method
- 2000 Trees
- 5 Depth
- 2 Min Obs
- .0001 Loss

Candidate Model Performance

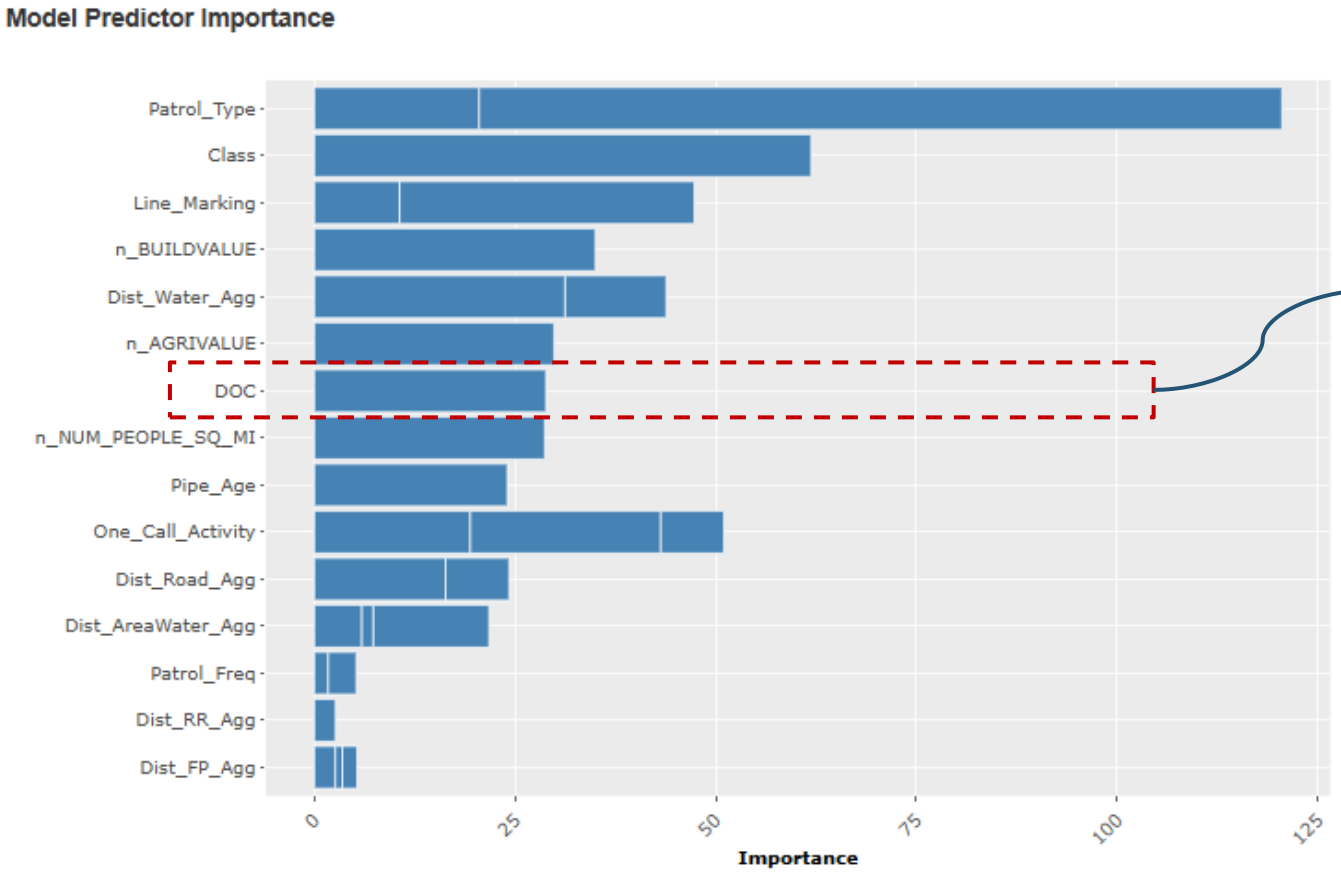


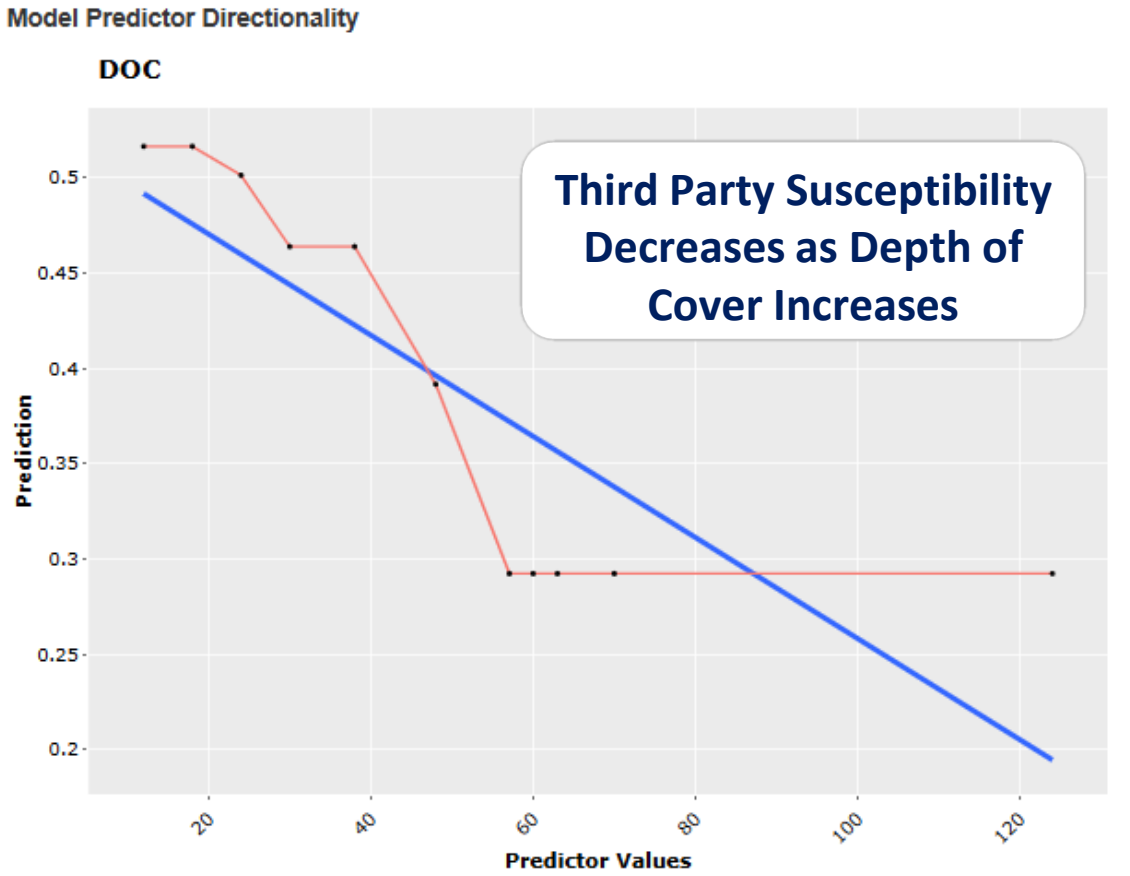
Candidate Model ROC's





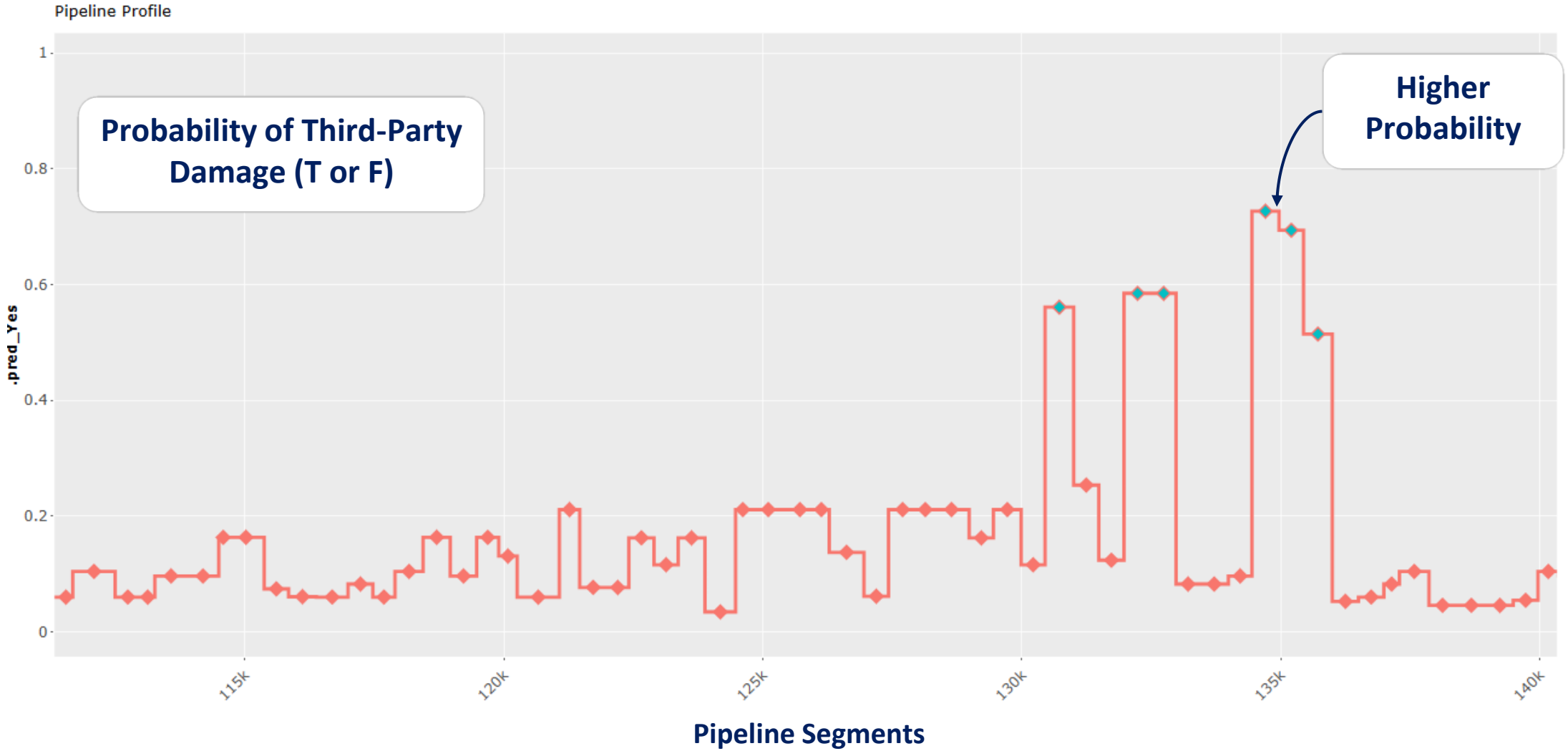
Learned Model – Global Weights



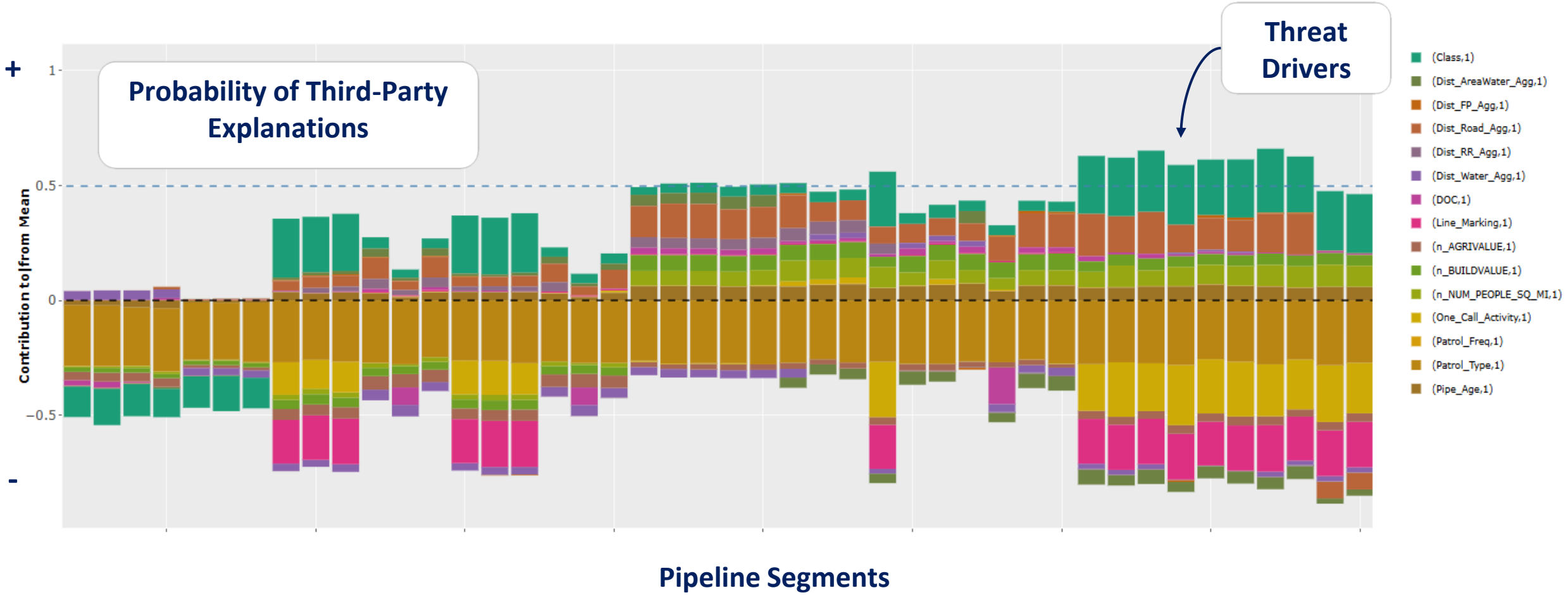


Third Party Susceptibility Decreases as Depth of Cover Increases

Learned Model Application



Learned Model Application & Explanation

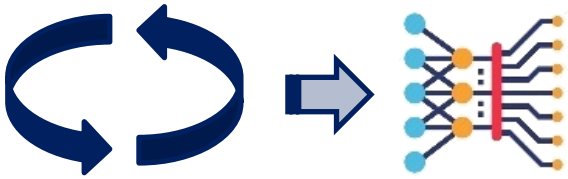


External Corrosion Severity (Regression)

Predictors

Learning Target	_Change	Dist_Road_Agg	DOC	n_AGRIVALUE	Nominal_OD	Pipe_Coating	Pipe_Seam	st_SOIL_cor
		All		All	All	All	All	All
2.05	-0.03	Limited_Impact	24.00	0.00	30.00	ASPHALT_ENAMEL	DSAW	High
2.05	-0.01	Out_Of_Range	30.00	0.00	30.00	TGF_E	DSAW	Moderate
2.00	-0.02	Out_Of_Range	24.00	0.00	30.00	TGF_E	DSAW	Moderate
2.00	-0.03	Limited_Impact	24.00	0.00	30.00	TGF_E	DSAW	Moderate
2.00	-0.03	Out_Of_Range	60.00	0.00	18.00	TGF_A	DSAW	High
2.00	-0.03	Out_Of_Range	63.00	0.00	18.00	TGF_A	DSAW	High
1.90	-0.07	Potential_Impact	24.00	0.00	30.00	TGF_E	DSAW	Moderate
1.85	-0.03	Out_Of_Range	18.00	0.00	30.00	TGF_E	DSAW	Moderate
1.80	0.02	Limited_Impact	24.00	0.00	18.00	FBE	DSAW	High
1.75	-0.03	Limited_Impact	24.00	0.00	30.00	TGF_H	DSAW	Moderate
1.70	-0.07	Limited_Impact	24.00	0.00	30.00	TGF_E	DSAW	Moderate
1.70	-0.07	Limited_Impact	30.00	0.00	30.00	TGF_E	DSAW	Moderate
1.70	-0.08	Potential_Impact	24.00	0.00	30.00	TGF_E	DSAW	Moderate
1.70	-0.08	Out_Of_Range	24.00	0.00	30.00	TGF_E	DSAW	Moderate
1.70	-0.07	Out_Of_Range	24.00	0.00	30.00	TGF_E	DSAW	Moderate

Training Data



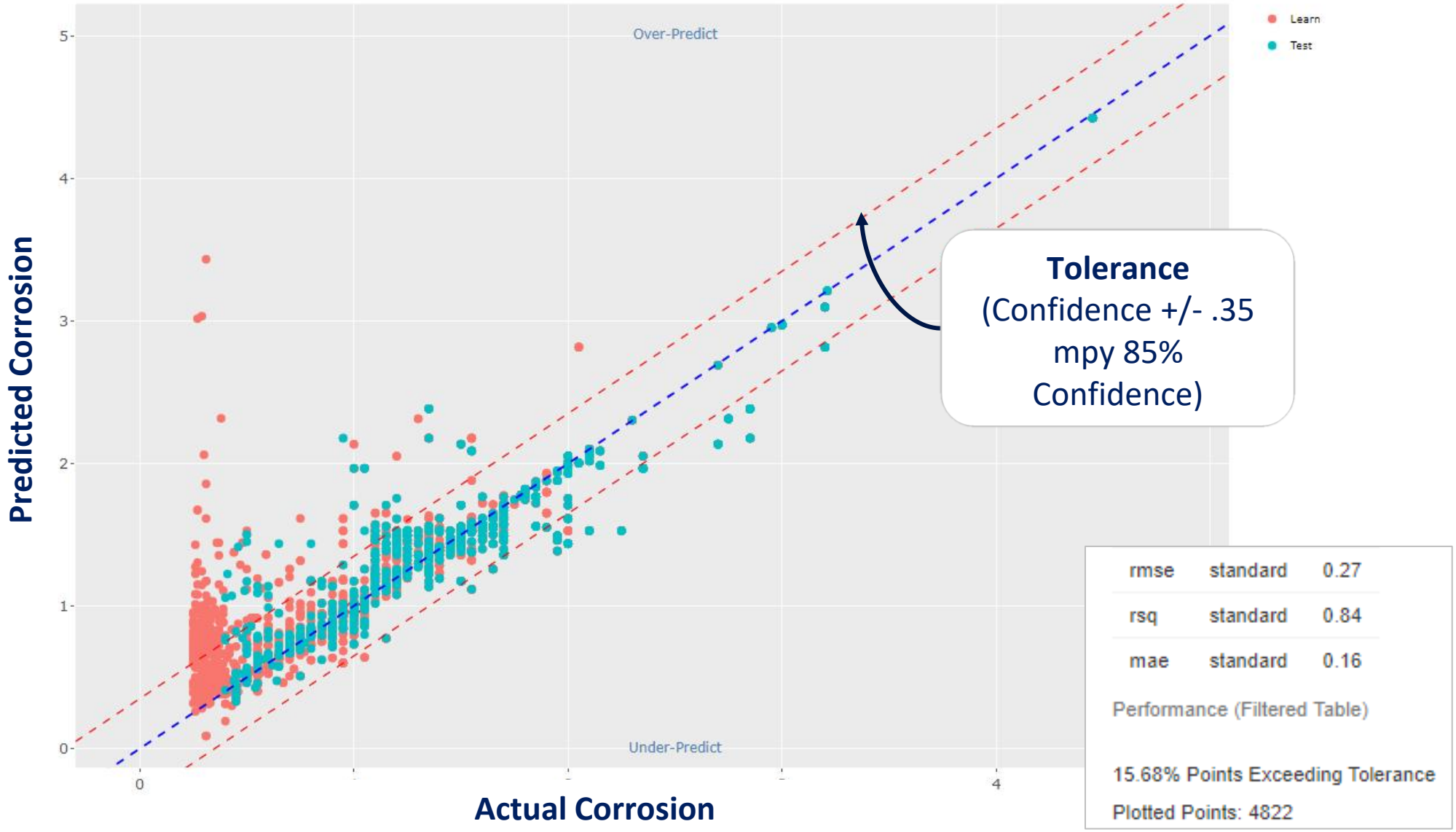
Machine Learning Process

Learned Model

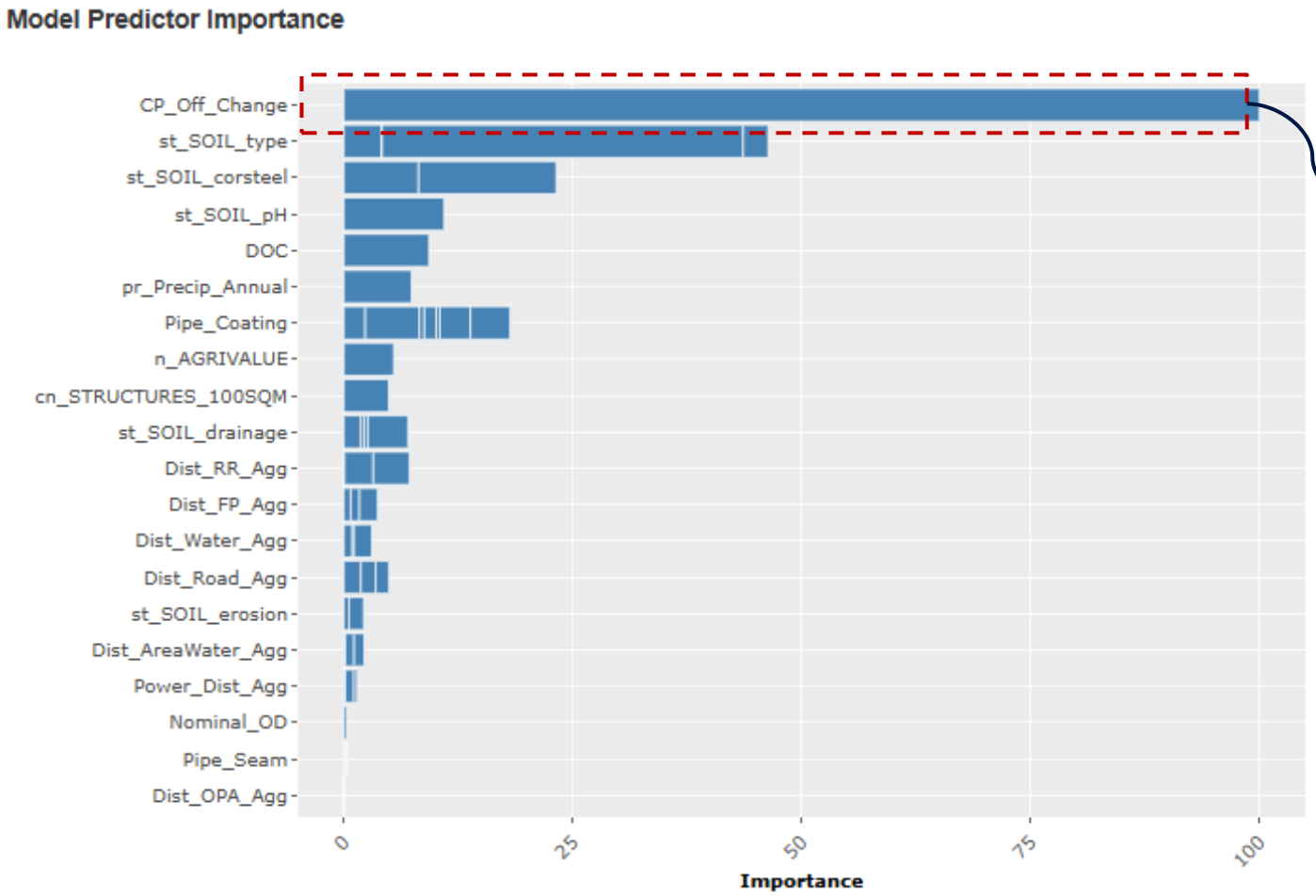
Learned Model Regression Performance

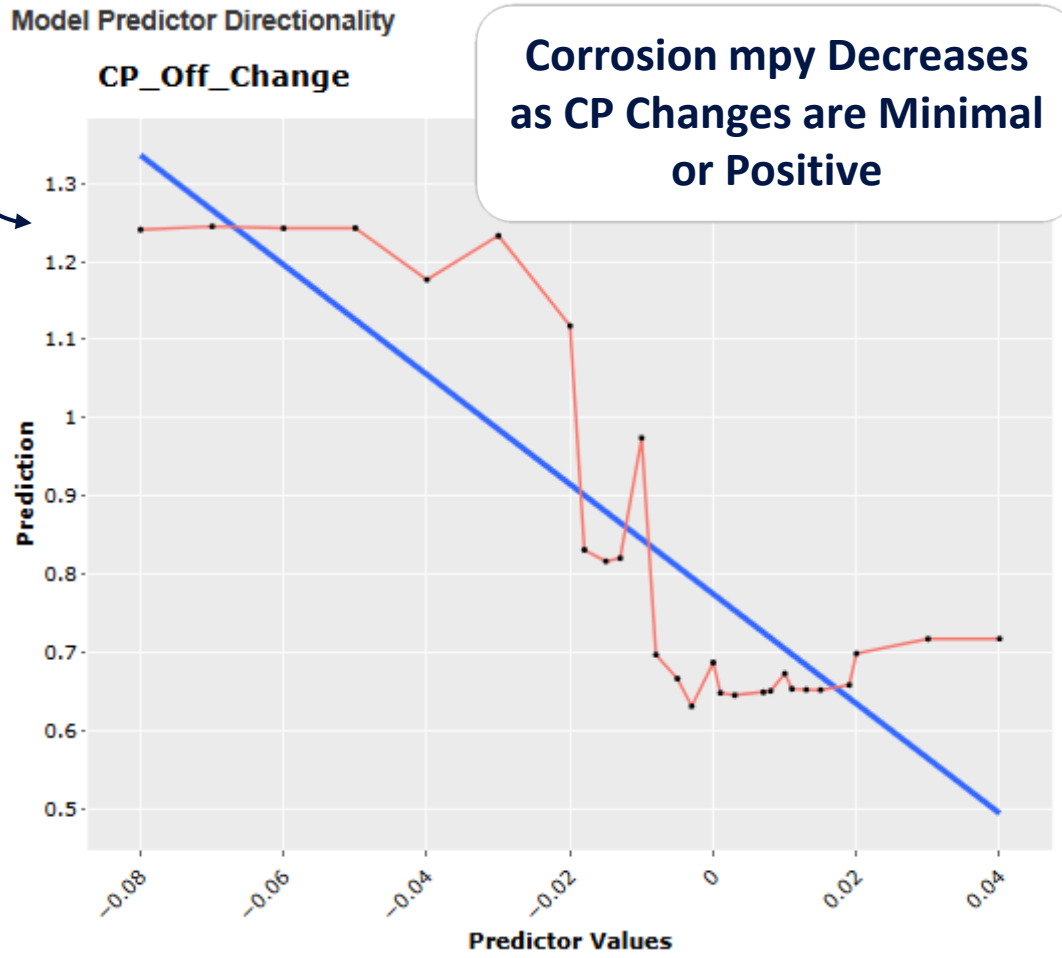
Metrics

- RMSE
- R2
- MAE



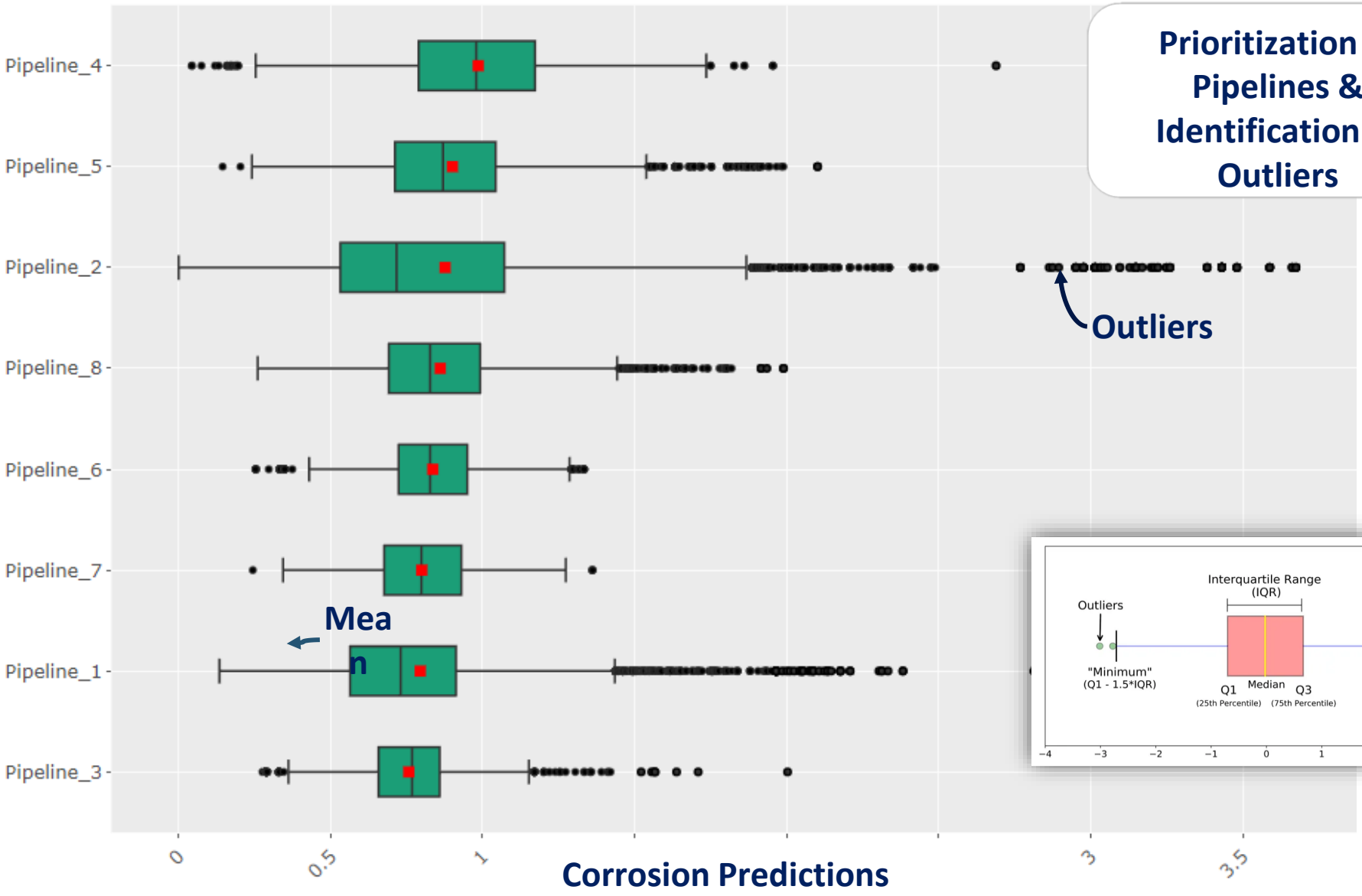
Learned Model – Global Weights



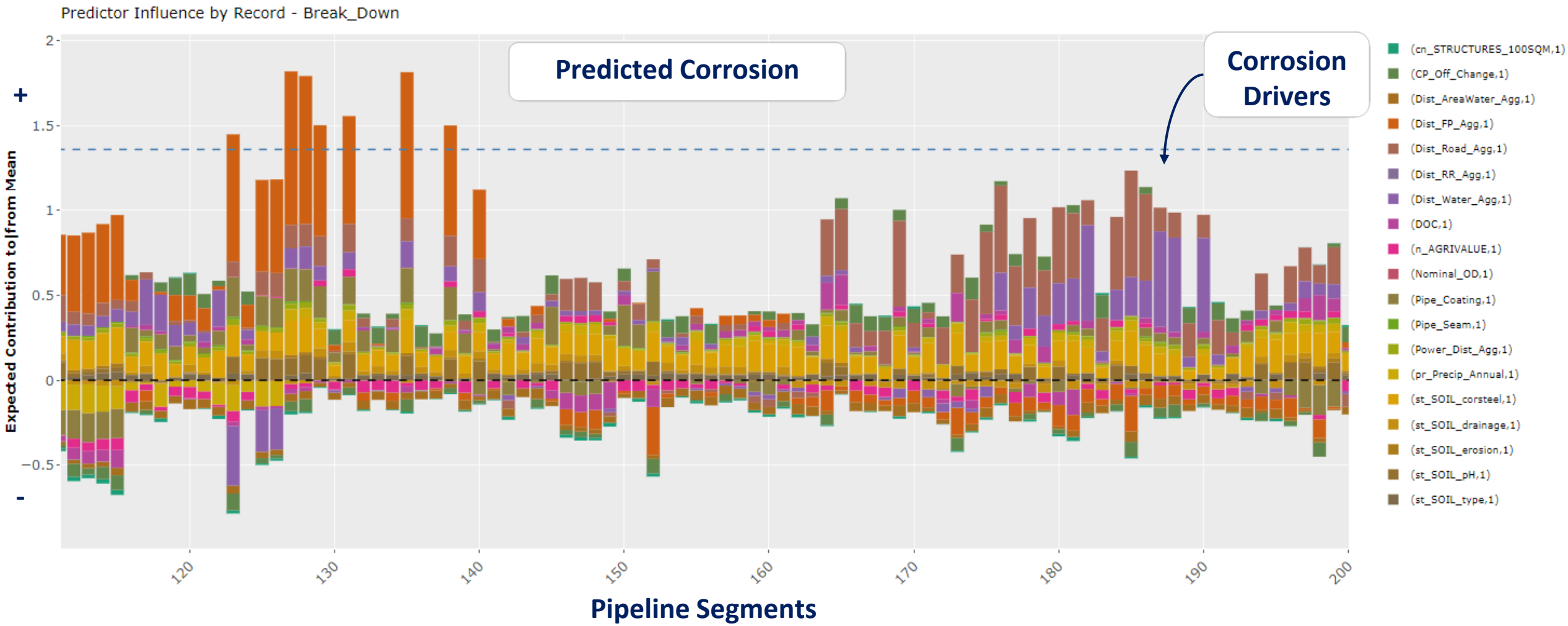


Corrosion mpy Decreases as CP Changes are Minimal or Positive

Learned Model Application

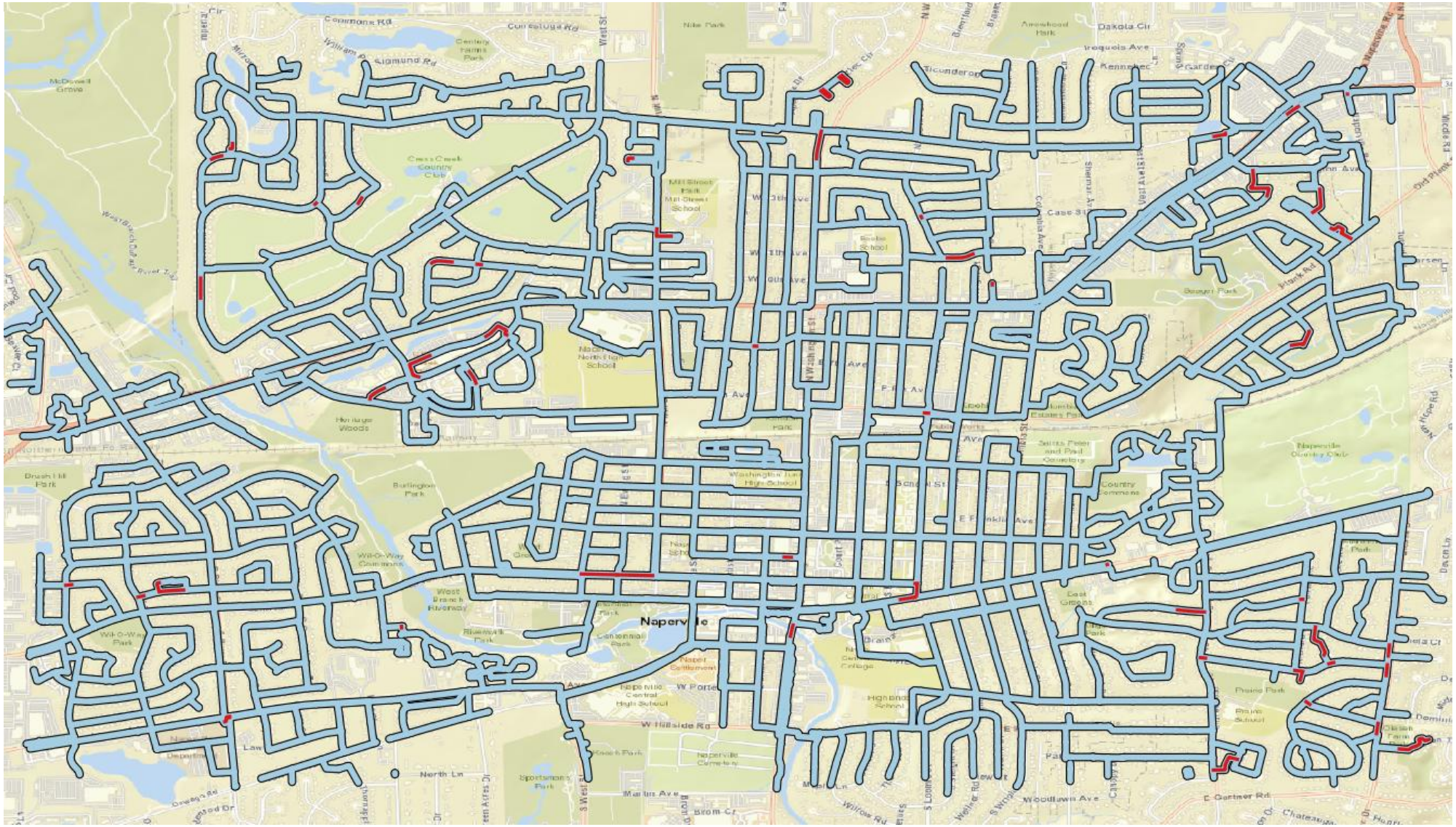


Learned Model Application & Explanations



Distribution System Monetized Risk (QRA)

Distribution System w\Leak Observations

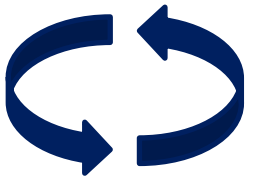


Predictors

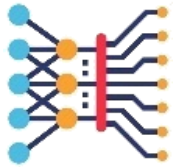
Learning Target (Leak Rate)

		ference	Coating_Type	CP_Reading	Diameter	Dist_FP	Dist_OPA	Material	MPY_Observed	n_AGRIVALUE	pr_Precip_Annu
			All	All	All	A	All	A	All	All	All
0.02	No		No Coating	-0.90	8.00	715.28		CAS	0.91	139.42	
0.00	No		PE	-1.90	8.00	328.09		STEEL	-0.18	0.00	
0.00	No		PE	-1.10	6.00	820.29		STEEL	0.49	345.31	
0.06	No		Unknown	-0.90	8.00			UNK	0.66	0.00	
0.00	No		PE	-1.60	6.00	1,712.54		STEEL	0.07	345.31	
0.02	No		TGF	-1.50	6.00	540.21		STEEL	0.16	345.31	
0.01	No		No Impact	0.00	6.00	88.33		PVC	-0.00	0.00	
0.01	No		Unknown	-0.70	6.00	1,334.41		UNK	0.83	0.00	
0.00	No		FBE	-1.60	6.00			STEEL	1.13	0.00	
0.00	No		FBE	-1.40	8.00	879.58		STEEL	1.30	0.00	
0.01	No		PE	-1.90	8.00	2,032.54		STEEL	-0.18	855.06	
0.01	No		PE	-1.90	8.00	2,018.25		STEEL	-0.18	855.06	
0.01	No		PE	-1.90	8.00	1,963.73		STEEL	-0.18	855.06	
0.01	No		PE	-1.70	8.00	1,961.68		STEEL	-0.01	855.06	
0.01	No		PE	-1.00	16.00	2,020.61		STEEL	0.58	855.06	
0.01	No		PE	-1.90	16.00	2,014.44		STEEL	-0.18	855.06	
0.01	No		PE	-1.30	16.00	2,222.94		STEEL	0.32	855.06	
0.00	No		PE	-1.80	8.00	2,179.92		STEEL	-0.10	855.06	
0.03	No		No Coating	-1.00				CAS	0.82	0.00	

Training Data



Machine Learning Process



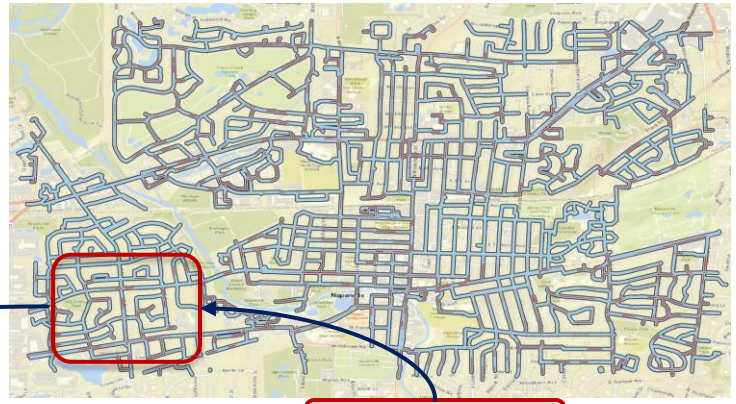
Learned Model

Learned Model Application (Predict Leaks)

Leak Probabilities (exceeding Criteria)

Model Explanations Defining Cohort Mitigation and Replacement Plans

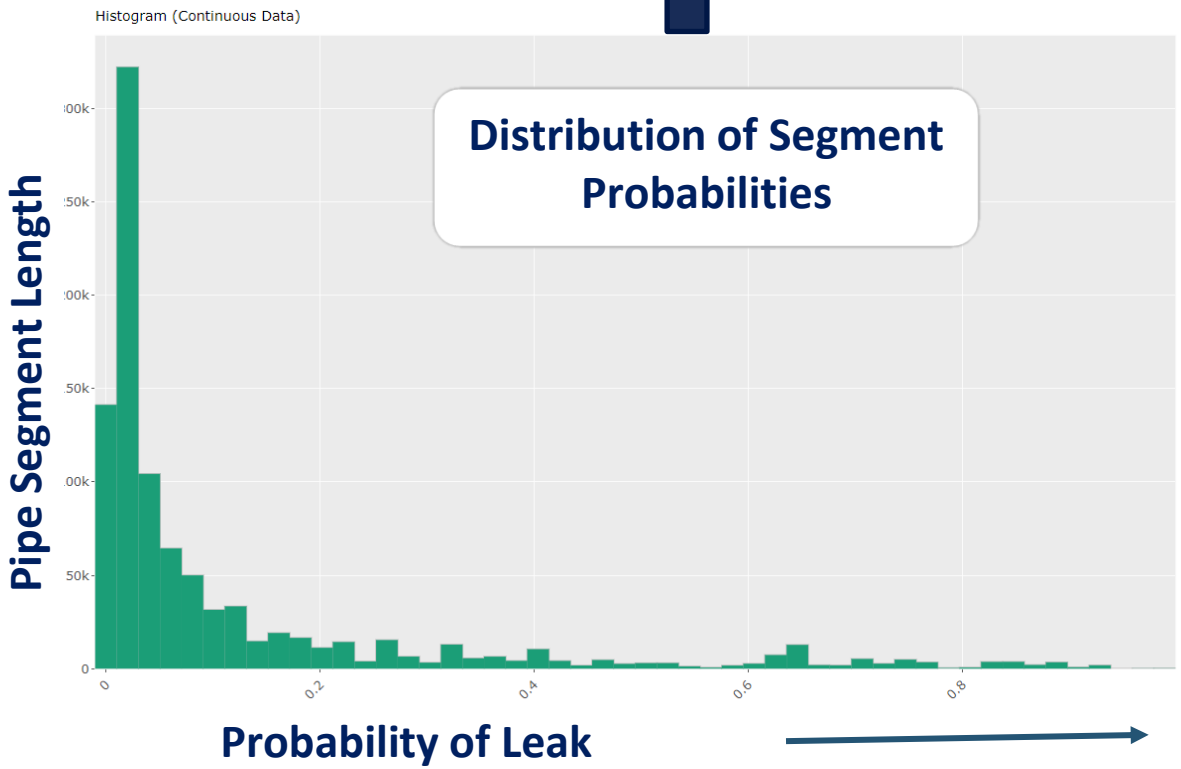
Higher Threat Risk Areas Driven by High Construction Activity

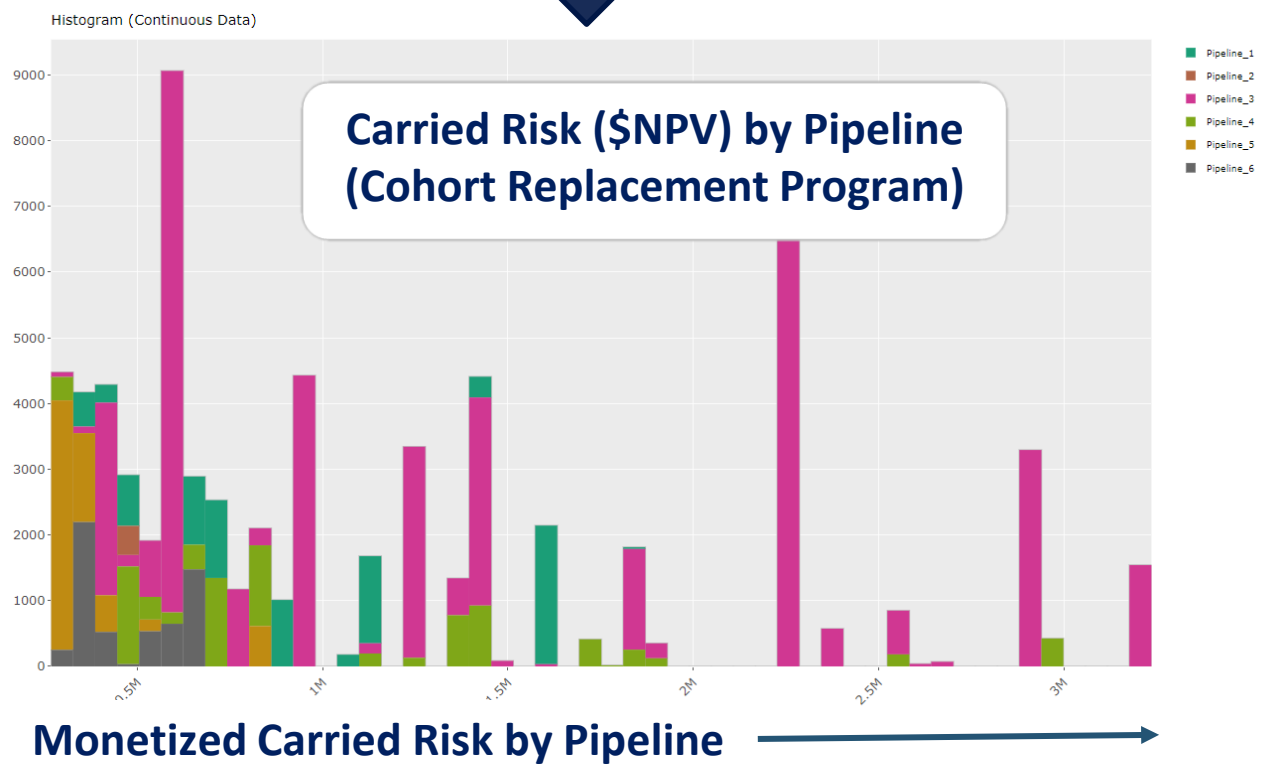


Monetized System Risk Distribution Leaks

QRA

- Consider resistance (pipe WT, toughness)
- Normalize to incident distributions (P50\P99)

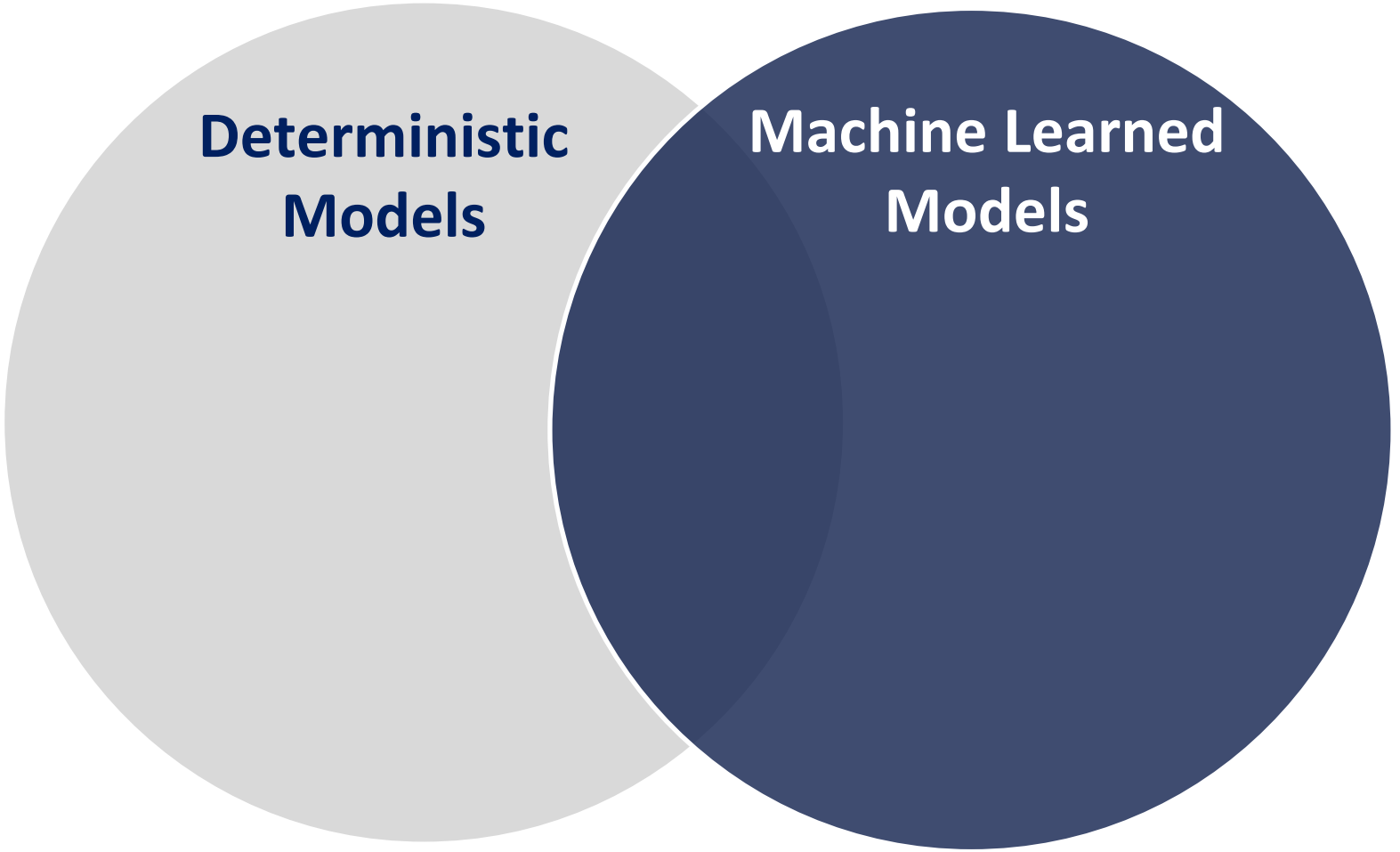




Machine Learned Results

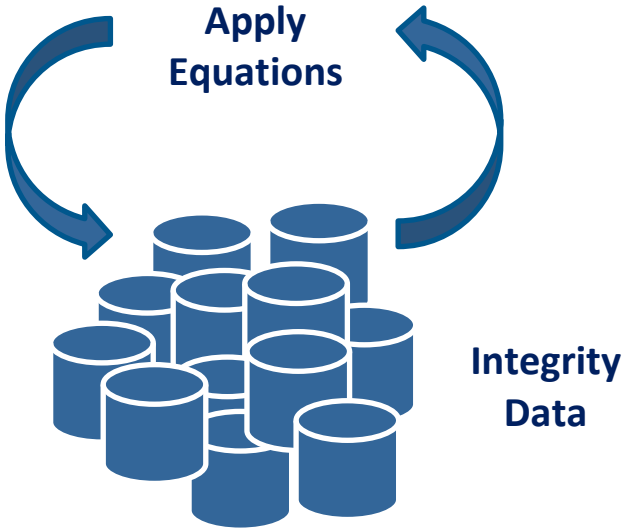
QRA Monetized Risk

Deterministic Model Validation

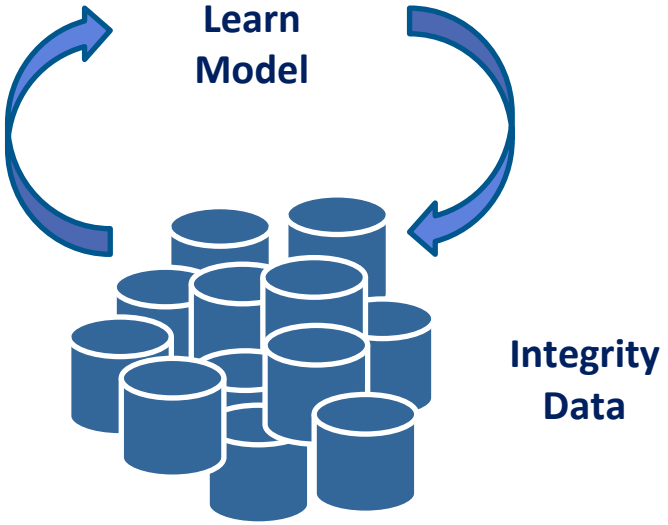


“Machine Learning Adapts Your Model To Your Business And Not The Business To Your Model”

Deterministic Models



Machine Learned Models

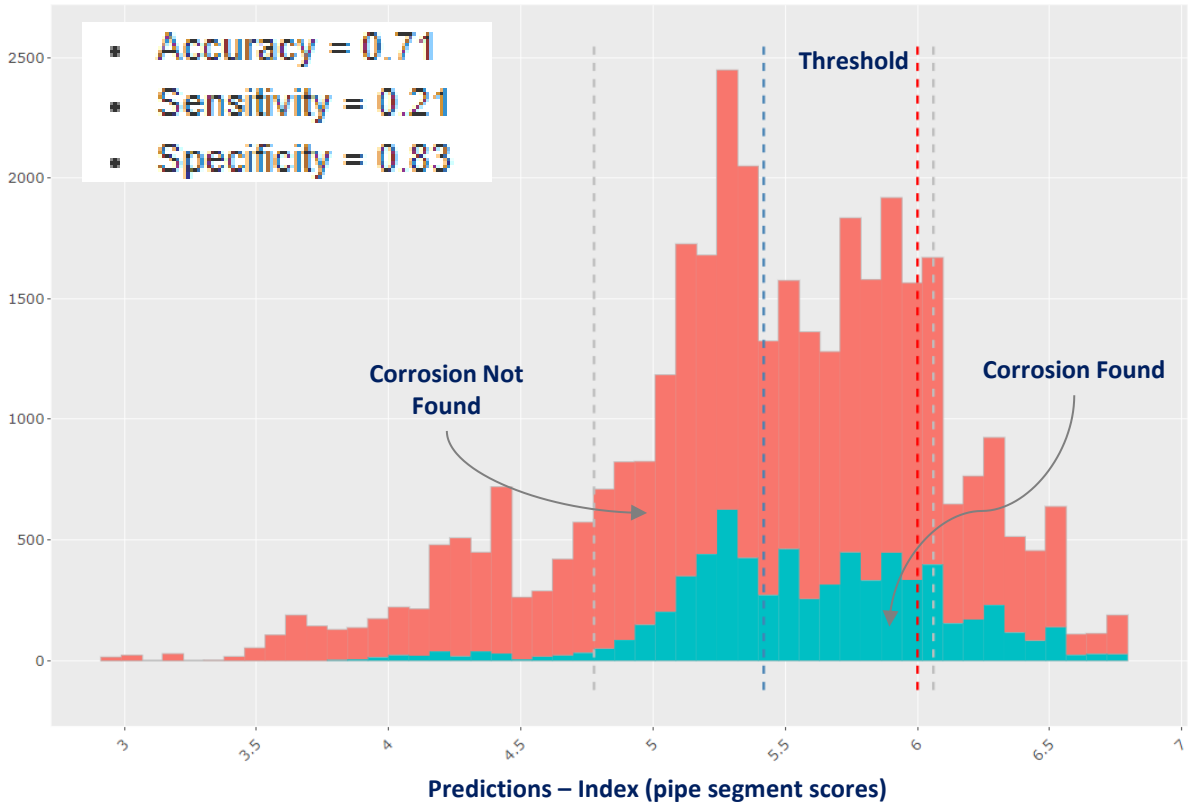


Same Integrity Data Used for Both Approaches

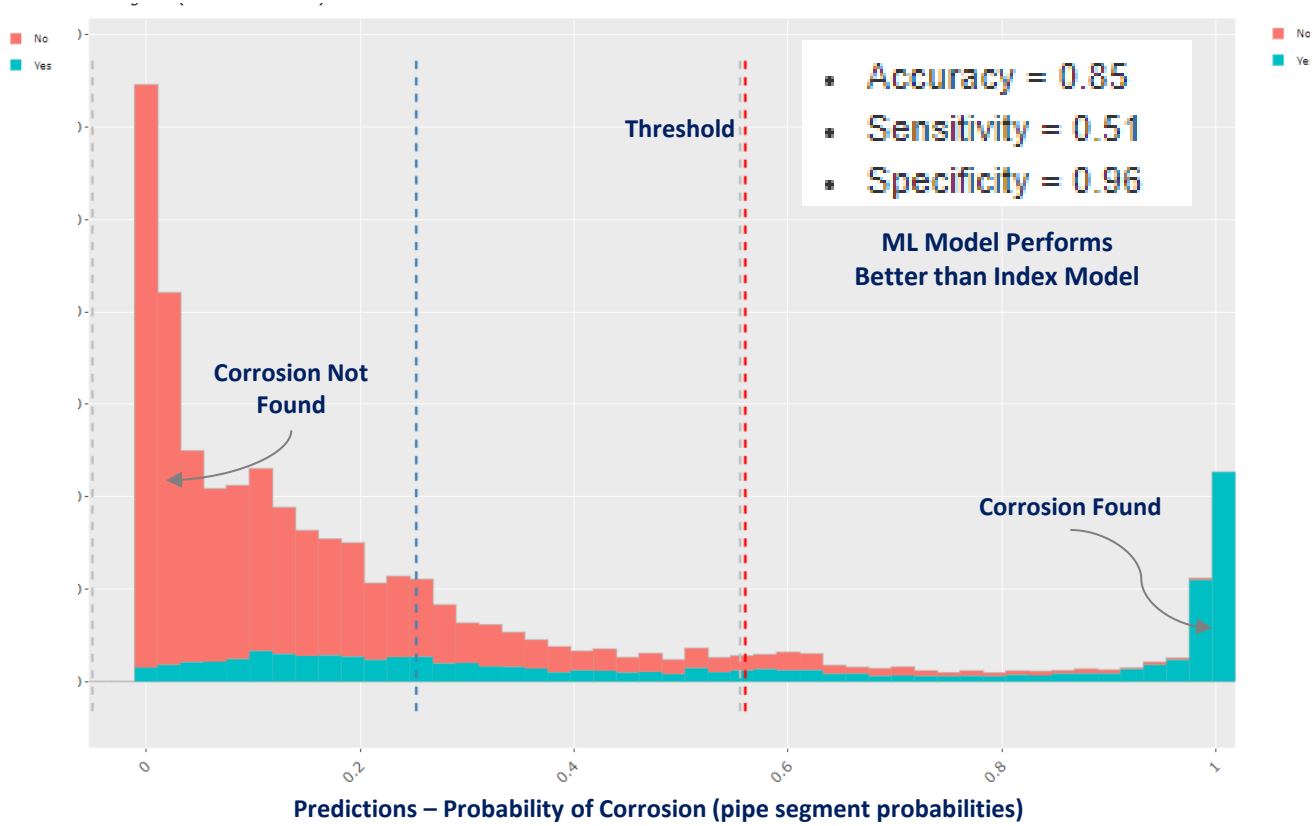
Deterministic vs. Machine Learned Performance

External Corrosion Example (Same Predictor Data - Deterministic vs. Machine Learned both Tested w\Observations)

Deterministic Model



Machine Learned Model



Model Learned based on Deterministic Structure

Model Learned with Observational Data

Summary

Value of Machine Learning to Integrity & Risk Management

- Data Driven – Leverage Existing Data
- Validated – Models are Explicitly Validated
- Explainable – Models & Results are Fully Transparent & Explainable
- Versatile – Process may be Applied to Wide Range of Use Cases

Resources

Open Source AI & ML Software

- R TidyModels
- Python scikit Learn
- LLM’s

SGA

Machine Learning for Pipeline Integrity Management

April 2nd - 3rd, SGA Facility in Dallas, TX

Additional Training: Introduction to Machine Learning with Hands-on Lab Exercises

Q&A

Asking a Question:

Please use the Questions Box in the control panel

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